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# The effect of choice options in training curricula on the demand for and supply of apprentices

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ABSTRACT

Building on Lazear's skill weights approach, we study the effect of having more or less heterogeneity in the training curriculum on the demand for and supply of apprentices. Modernizations of training curricula provide us with a quasi-experimental setting as these modernizations can be seen as a relatively exogenous shock. We argue that firms will train more apprentices when they have more choice options in the training curriculum because of (1) the higher productivity of graduates who have acquired more skills that are relevant for the firm, and (2) firms' higher market power in the wage bargaining process with graduates. We test this hypothesis on data on the demand for apprentices in Germany in all occupations from 2004 to 2014. We find that a more heterogeneous curriculum increases both firms' demand for and the supply of apprentices.



## 1. Introduction

The dual apprenticeship system in Germany plays an important role in integrating young people into the labor market and in safeguarding a skilled workforce. More than 50% of each cohort starts an apprenticeship program each year (Uhly, 2015). As firms can freely decide whether they provide training places or not, it is important to understand the incentives and conditions under which firms are willing to provide training places. The analysis of the demand for apprentices has so far focused on demographic developments, the business cycle, and alternative recruitment possibilities on the external labor market (Dietrich & Gerner, 2007; Maier & Walden, 2014; Mühlemann, Wolter, & Wüest, 2009; Troltsch & Walden, 2010). However, none of these studies has related firms' demand for apprentices to the content of the training curriculum.

According to the Vocational Training Act (§ 4, 2), training firms have to impart a pre-determined set of skills defined in a standardized curriculum when providing training places in a recognized occupation of the dual system. While some occupations allow for specialization opportunities in their training curriculum, apprenticeship training courses for other occupations are designed as "mono-occupations", in which every firm has to teach exactly the same skills. However, due to technological and organizational developments, training curricula are sometimes modernized. A modernization of the training curriculum for a particular occupation often does not only change the content of the curriculum but also changes the number of choice options training firms have. Since the 1990s, for example, a tendency toward more heterogeneity in the training curricula could be seen (Bretschneider & Schwarz, 2011; Demgenski & Icks, 2003). Table 2 in Section 4 provides an overview of the frequency of the different types of curriculum modernizations.

In this paper, we use these relatively exogenous changes in the regulatory framework of apprenticeship training to assess the impact of having choice options on firms' demand for apprentices as well as on youngsters' willingness to enroll in certain occupations within the dual apprenticeship system. Observing a longer time horizon one might argue that the contents of the training curricula respond to the firms' production processes and are therefore

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**Table 1**
Overview of expected effects of curriculum modernizations.

| | Demand for apprentices | Supply of apprentices |
|---|---|---|
| Modernization | + (H1) | + (H3) |
| More heterogeneity | + (H2) | +/- |
| Less heterogeneity | +/- | +/- |

rather endogenous in the long term. However, modernizations do not immediately respond to changes in the production process as they involve quite an administrative effort and corresponding costs. As various stakeholders are involved in the process, the exact year a new curriculum is implemented can be seen as relatively random. Therefore, we argue that in the short run, observing a time period of about 10 years, the modernizations can be considered as an exogenous shock, which decreases the gap between required and imparted skills from one training year to the other substantially. A more tailor-made training content enables firms to train their apprentices in a way which is more closely aligned to what the firm really needs. This will render the apprentice more productive both during the training period and after completion of training, whereas training which is closer to the production process of the firm is less complicated to organize, something which could reduce training costs. Moreover, a more specialized curriculum increases the market power of the training firm because apprentices who have completed training can only apply their skills in fewer outside firms. As a result, firms are able to pay lower wages upon the retention of the apprentices, something which increases their incentives to provide apprenticeship places.

From the firms' perspective, the positive aspects of having more choice options seem to be undisputed. The results of a firm survey conducted on behalf of the former German Federal Ministry of Economics and Labor in 2005 (Ramboll Management, 2005) indicate that different aspects of the training curricula, such as content and structure, play a crucial role in a firm's decision on whether or not to offer apprenticeship places. Indeed, 53% of all non-training firms state that allowing for more freedom in the training organization would ease the initiation of training (Schönfeld et al., 2010). Demgenski and Icks (2003) also argue that too restrictive training curricula can be a severe obstacle to providing training. They show that 54% of former training firms see the lack of specialization opportunities as a huge impediment to continue to provide apprenticeship training. Having choice options in the curriculum is therefore likely to increase firms' commitment to apprenticeship training.

Apprentices, on the other hand, do not necessarily have the same interests as the firms that offer apprenticeships. More specialized training means that apprentices who have completed training have worse chances of finding a job in other firms because their skills then only match the skill demands of fewer other firms. If apprentices are not sure whether they will be retained upon completion of training, a too specialized curriculum may not be attractive for them. However, a more specialized training can also make the apprentice more productive in the training firm as the imparted skills correspond more closely to the firms' skill needs in the production process. If the higher productivity is to some extent reflected in a higher wage, the introduction of more choice options for firms could also increase the attractiveness of training from the apprentice's point of view.

In this paper, we explain the development of the demand for and supply of apprentices after a change in the number of choice options in the course of a modernization. As long as training costs do not increase substantially, the number of firms providing apprenticeship training will increase in line with increasing post-training benefits.

Using data on the demand for and supply of apprentices in Germany for 265 occupations over 11 years, we analyze the effect of curricula modernizations on training supply and demand empirically. The information about the modernization of the training curriculum is obtained by comparing the training curricula before and after modernizations. In total, 85 modernizations were analyzed. Our empirical analyses show that both the demand for and supply of apprentices are positively affected by the introduction of more choice options in the training curriculum. This shows that leaving sufficient freedom in the training regulation improves the attractiveness of the dual system for firms as well as for apprentices.

Our study contributes to the human capital literature on training by analyzing the effect of curriculum heterogeneity on the demand for and supply of apprentices. The heterogeneity of training curricula might be an important aspect of the firms' willingness to train. This issue is highly relevant for designing (new) training regulations, within existing apprenticeship systems as well as for countries that aim to introduce elements of an apprenticeship system. Taking this knowledge into account can ensure the attractiveness of the apprenticeship system both from the firms' and the students' points of view. The insights provided in this paper can also be transferred to other centrally regulated or certified training courses.

The paper is structured as follows. In the next section, we discuss the relevant literature that provides the theoretical background to our empirical analysis. Section 3 describes the main features of the German apprenticeship system and discusses the choice options in training curricula. Section 4 presents the hypotheses on the effect of modernizations on the demand for and supply of apprentices. Section 5 discusses the data and explains how the degree of choice options of the curricula is determined. Section 6 presents the empirical strategy to test the derived hypotheses and discusses the exogeneity of the curriculum modernizations. Section 7 presents the estimation results and Section 8 concludes.

## 2. Literature

While some firms train because they want to make use of the productive contributions of the apprentices, other firms decide to offer training places mainly because they want to retain the apprentices as skilled workers after the training period (Merrilees, 1983). In the former case, firms actually do not bear any training costs as the productive contributions already compensate for the training expenses. In the latter case, firms regard the training costs as an investment, which they can recoup upon the retention of the apprentices. As rational firms only decide to train when expected benefits exceed expected costs, firms need to be able to pay a wage below skilled workers' productivity in order to recoup their training costs. However, paying a wage below workers' productivity is only possible when the firm has a certain market power over its employee. Becker (1962) showed that firms have no incentives to pay for training in general human capital. If firms pay a wage below a worker's productivity after the training, the employee would leave the training firm and find a firm that offers a wage equal to his or her productivity. Firm-specific human capital, in contrast, can only be utilized in the training firm. Therefore, firms would be only willing to invest in firm-specific human capital. Acemoglu and Pischke (1999b, 1999a), however, expand Becker's theory by arguing that in non-competitive labor markets under the existence of wage compression, firms are also willing to pay for general human capital. Dionisius et al. (2009) showed that Germany is such a case, where the compressed wage structure leads to substantial post-training benefits, and in the same way to a willingness to incur training costs. As most occupations are asso-

ciated with net training costs (see Schönfeld et al., 2010), one can expect post training benefits for most occupations.

Stevens (1994) identifies a third group of skills, which she terms as transferable skills. Although these skills can be deployed in more firms, and are thus, technically seen, general skills, the wage does not have to equal the productivity of the person who has completed training because of the low degree of competition for these skills. Occupation-specific skills are a clear example of such transferable skills. Occupation-specific human capital denotes a set of skills that are merely useful within one occupation. Wolter and Ryan (2011) explain that these occupation-specific skills create monopsony power for the training firm as they limit the number of potential outside firms where trained workers could employ their skills.[1] As a result, workers' productivity related to these occupational skills is not fully reflected in their wages. Also Bhaskar, Manning, and To (2002) argue that when employers have some market power, they may have an incentive to pay for general human capital as the skilled worker wage will be lower than their marginal product. The more market power a firm has, i.e. the fewer firms where skilled employees could move to, the more likely firms are, ceteris paribus, to invest in training. Smits (2007) shows that, firms would only prefer to convey occupation- or industry-specific skills if the training was not regulated otherwise. Even if workers paid for general skills, firms have no interest in providing workers with general training because the returns to industry-specific skills decrease with the share of general human capital.

Lazear (2009) argues that skills can be *de facto* firm specific, even if they are technically general, when the combinations of these general skills are specific to firms. He terms this concept the "skill weights approach" as each general skill has different weights in different firms. One essential outcome of the skill weights approach (SWA) is that firms that use more idiosyncratic skill weights, i.e. a combination of skills that is very different to the average combination of skills in other firms, are more willing to bear training costs as they can pay relatively lower wages after the training period. Lazear notes that the specificity of the skill combination does not necessarily mean that it is specific to one firm. It can also be related to industries, occupations, or specific jobs. Translated into occupation specific skills, this would imply that firms training in occupations in which the required skills are very idiosyncratic are more likely to bear training costs. Geel, Mure, and Backes-Gellner (2011) test this hypothesis and indeed find that more idiosyncratic skill weights in an occupation imply higher training investments on the part of the firms. This mechanism is supported by the finding of Hofmann, Damelang, and Schulz (2011), who analyze the effect of specificity of occupations on the probability that workers change their occupation. In accordance with the concept of the skill weights approach, they find that the more specific an occupation is, the less likely it is that employees change their occupation. Analyzing the skill bundles of 80 Swiss VET occupations, also Eggenberger, Rinawi, and Backes-Gellner (2015) find that workers trained in very specific occupations are less likely to change their occupation. Further, in case workers change to occupations with very different skill bundles, their wage loss is higher than if they change to rather similar occupations. Moreover, Rinawi, Krapf, and Backes-Gellner (2014) find that, after a layoff, individuals with more occupation-specific skill bundles remain unemployed for a longer time period and are less likely to find a job in a different occupation. Also Gathmann and Schönberg (2010) emphasize that the specificity of human capital is due to different combinations of skills, even if the skills themselves are transferable. To measure the degree of skill specificity, they calculate the task combinations of different occupations and find that individuals are more likely to switch to occupations with similar task requirements. They show that workers who move to a more distant occupation suffer from higher wage losses than workers who move to more similar occupations.

While these analyses focus on the mobility between different occupations, mobility within occupations to other firms is also a great threat for the training firm. The German labor market is very occupation specific and one can safely assume that, unless an unexpected change occurs, apprentices plan to stay in their occupation upon completion of training. Hall (2015) finds that in the first year after completion of training fewer than 4% of all apprentices switch to an occupation that is not related at all to the occupation in which they have been trained. 24% switch toward a related occupation, whereas 72% of all apprentices stay in the occupation they have learned. For comparison, data from the BIBB Cost–Benefit Survey show that 56% of all apprentices do not leave the training firm within the first year upon completion of training.[2] About 8% of all former apprentices remain in the training firm but switch their occupation (Fitzenberger, Lickleder, & Zwiener, 2015). Thus, mobility of those who successfully completed their apprenticeship training to other firms within an occupation is also of high importance.

However, also within an occupation, there is quite some variation in the production process.[3] Firms may have apprenticeship places for the same occupation but have different specializations. An occupation could, for example, need two main skills, but not all firms in this occupation might need these two skills to the same degree. Thus, firms training apprentices in the same occupation could also differ with respect to the weights they give to certain skills. Accordingly, Lazear's SWA can also be applied to the distribution of skill weights within an occupation. If firms could choose the training content freely, they would only train those skills that are relevant for their own production process. However, in the institutional setting of the German apprenticeship system, strict training curricula dictate the skills the firms have to provide during training.

Therefore, Lazear's skill weights approach does not fully match the settings of the German apprenticeship system. The skills, which are the main choice variables in Lazear's model, cannot be freely chosen in the case of apprenticeship training. However, in the last years, modernizations in training curricula have often given more freedom to training firms by including more choice and specialization options in the curricula, which allow the firms to train their apprentices in a way which is more closely related to their production process. In terms of the SWA, this means that firms can choose their skills more in line with what they would do if they could freely maximize their surplus. Creating more choice options in apprenticeship training also means that persons successfully completing training can apply their skills in fewer outside companies, which gives training firms more market power. This implies that firms can retain a higher share of the workers' productivity by paying lower wages, which leads to an increase in the expected long-term benefits of training for the firms. As long as training costs do not increase substantially, the introduction of choice options in the training curriculum will therefore increase firms' demand for apprentices.

## 3. The German apprenticeship system

Apprenticeships in Germany are a combination of work place training and theoretical learning in a vocational school. The ap-

[1] Also other sources of monopsony power can exist such as a low regional density of firms.

[2] Own calculations on the data.

[3] Even though the variation within an occupation might be lower than the variation between occupations.

prentice spends about 3–4 days of the working week in the firm and about 1–2 days of the week in the vocational school. The firm is, therefore, an important learning venue, in which the practical skills required for the examination are taught. The firm and the apprentice sign a training contract, in which the training occupation, apprentice pay and training conditions are specified. By signing the training contract firms commit themselves to the provision of training outlined in the curriculum of the respective occupation (Vocational Training Act § 4, 2). At the end of the training period, the competent authority, e.g. the Chamber of Industry and Commerce for Industrial and Commercial Occupations, examines whether the apprentice has acquired the practical competencies prescribed in the training curriculum. Moreover, the Chamber is responsible for assuring the training quality and therefore supervises the training given in the firm. Although firms have some scope in the way how they impart the prescribed skills, firms have the responsibility to train the apprentice for the final exam.

The training curricula for the firms are developed at the national state level, and are therefore the same for all firms in Germany. Nonetheless, some curricula provide the firms the opportunity to choose between different specializations. This specialization has to be mentioned in the training contract.

*Mono-occupations*[4] are occupations without any specialization. Thus, the training content is identical for all firms training apprentices in the occupation. However, there are also occupations with curricula that allow for differentiation. Then firms can choose between training courses with special training content for different fields of activity. For example, in some occupations firms have to choose different *fields of application*. Even though the concrete competencies that have to be taught are the same, they can be imparted in different fields. In other occupations, firms can choose *priority topics*, which take company characteristics into consideration and account for not more than 6 months out of the entire training period that lasts between 2 and 3½ years. Even more differentiation is possible in occupations with different *disciplines*. A discipline is a specialization that has to be taken in the third training year and is also tested in the final exam. The highest degree of differentiation within an occupation is obtained by the use of *elective qualification units*. Usually several out of many possible units have to be chosen, which leads to a high number of different possible combinations within one occupation. In these occupations, firms have most possibilities to adapt the training content to their specific skill requirements. However, *elective qualification units* vary in the time they constitute of the total training time. In some occupations, they only account for half a training year, while in other occupations they account for a full training year.

At the end of the training period the apprentice receives three different types of certificates: one from the vocational school, one from the employer and one from the Chamber that is responsible for the occupation. The Chamber issues a certificate including information on the examination results and the chosen specialization. The disciplines are even part of the official name of the occupation. In this way, the chosen specialization is visible for all other employers. According to the Vocational Training Act, the certificate from the employer has to include information on the acquired capabilities and competencies, which usually also include information on the specialization, and the certificate from the vocational schools includes information on the chosen specialization when the school provides different classes depending on the specialization.

When an occupation is not up-to-date anymore, it will be modernized. The initiative for a modernization of the curriculum may come from any of the relevant stakeholders such as employer associations, unions, representatives of the federal states, representatives of the national government, or the Federal Institute for Vocational Education and Training (BIBB). Before a new curriculum is adopted, all relevant stakeholders have to agree with it. Then, the relevant ministry, in agreement with the Ministry of Education and Research, grants state recognition to apprenticeships and enacts the training curricula according to the Vocational Training Act (§ 4,1).

## 4. Theory and hypothesis

In this section, we will outline the expected effect of a modernization on the demand for apprentices in this occupation and briefly elaborate on the relation between modernizations and the supply of apprentices.

### 4.1. Demand for apprentices

In our analyses, we will differentiate between the effect of a modernization as such, in the sense of an adjustment of the training content, and the effect of a change in the number of choice options training firms have. First, we outline the hypothesis on changes of the content of the curricula irrespective of the degree of differentiation. Second, we discuss the effect of a change in the number of choice options. We argue that a more specific training curriculum will increase the productivity of the graduates and enable the firm to pay the skilled workers a relatively low wage after the apprenticeship.

#### 4.1.1. Effect of changing the content of training curricula

A modernization of the content of the curriculum always implies an adaptation of the training curricula to technological developments. Therefore, modernizations align more closely the skills learned in the training with the skills demanded in the occupation and thus make apprenticeship training more effective. As a result, workers who successfully complete modernized apprenticeship training will ceteris paribus be more productive. If workers and employers equally share the returns on this additional productivity, firms have more incentives to train and workers are more likely to opt for a modernized occupation. As long as the wage increases less than graduate's productivity,[5] the return for the training firms increases. This will induce them to increase their demand for apprentices. This leads to the following hypothesis:

***H1:*** *A modernization of the training curriculum leads to a higher demand for apprentices in this occupation.*

#### 4.1.2. Effect of more and less heterogeneity within the curricula

Apart from the adaptation to technological development, a modernization is often associated with a change in the number of choice options in the curriculum. More choice options would then lead to more heterogeneity, while fewer choice options lead to less heterogeneity in the curriculum. The effect of heterogeneity on firms' post-training benefits can work via two mechanisms:

- the degree of heterogeneity has a positive effect on the productivity of apprentices who have successfully completed training;

[4] In the following, we use the terminology that is also employed in the English version of the official BIBB leaflet about training regulations (Bundesinstitut für Berufsbildung, 2014).

[5] For now, it can be assumed that the rent the firm retains is a constant share of a worker's productivity. Acemoglu and Pischke (1999a) also argue that for higher training incentives it is not necessary that the share of a worker's productivity that the firm retains increases. Even if the firm retains a constant share of the worker's productivity as a rent, post-training benefits are higher for more productive workers as the "firm obtains a share of this larger pie" (p. 121). Later, we will relax this assumption in the way that the share of the wage in relation to the productivity decreases. Then, the effect on firm-sponsored training will be even stronger.

- the degree of heterogeneity has a positive effect on the firms' market power.

Both mechanisms will be outlined below.

#### 4.1.3. Effect via the productivity of apprentices successfully completing training

In order to explain the effect of heterogeneity on the productivity of apprentices who have successfully completed training, we employ elements of the argumentation in Lazear's skill weights approach. Similarly to Lazear's skill weight model, we assume that (1) a firm i in a given occupation produces with the skills A and B, and (2) that firms employing workers with this occupation need different combinations of these two skills. The weight for skill A in firm i is denoted with $\lambda_i$, which ranges from 0 to 1. $\lambda_i$ is a random variable with the density function $f(\lambda_i)$.[6] The worker's production function $Y_i$ in firm i depends on the worker's skills A and B, and is as follows[7]:

$$Y_i = (A \cdot \lambda_i)^{(1/2)} + [B \cdot (1 - \lambda_i)]^{1/2} \quad (1)$$

Moreover, each firm has a maximum total training time for an apprentice, which has to be split between the two skills A and B. Assume that $\alpha$ represents the time allocation between skills A and B and lies between 0 and 1. Then, the time available for learning skill A is equal to $\alpha$ and the time available for skill B is equal to $1 - \alpha$. Plugging in $\alpha$ for A and $(1 - \alpha)$ for B, the production function could be solely written as a function of the allocation of training time to the two skills:

$$Y_i = (\alpha \cdot \lambda_i)^{(1/2)} + [(1 - \alpha) \cdot (1 - \lambda_i)]^{1/2} \quad (2)$$

The production function with the exponent of one half is designed in such a way that the worker is most productive if the training time for skill A ($\alpha$) equals the firm's skill requirement for skill A $\lambda_i$. The higher the difference between $\alpha$ and $\lambda_i$, the lower the worker's productivity in firm $i$ will be. If firms could freely maximize their surplus, they would choose $\alpha$ equal to $\lambda_i$.[8]

However, in contrast to Lazear's model, in German apprenticeship training time allocation $\alpha$ between the skills A and B is externally determined by the training curricula. As firms' training decisions depend on the expected productivity of the trained workers, this setting implies that firms' training decisions depends on the $\alpha$ set in the curriculum. The lower the difference between $\alpha$ and $\lambda_i$, the more likely it is that the firm will invest in training. As this is true for any individual firm, the demand for apprentices in a given occupation rises in line with lower aggregated differences between the skill requirement and the skills prescribed in the training curricula $\int_i^N \alpha - \lambda_i$, where N is the total number of firms.

In a mono-occupation, $\alpha$ is the same for all firms. If there are choice options in the training curriculum firms can choose between several $\alpha$, i.e. specialization opportunities. To predict the effect of a change in the heterogeneity of the training curriculum, one needs to know in which case total productivity is highest. This depends on the amount and type of the choice options $\alpha$ and on the distribution of the production processes of the firms employing trained persons in the occupation: $\lambda_i$. Creating more heterogeneity in the curriculum will have a positive effect on aggregated productivity if firms' production processes are characterized by a strong specialization of skills. However, less heterogeneity could also have a positive effect on aggregated productivity, if all firms training for the same occupation have a very homogenous production process. In such a case, specialization would be counterproductive. A modernization which implies a change in the degree of heterogeneity of the curriculum usually occurs because relevant stakeholders have requested this change. One main characteristic of the German apprenticeship system is the "consensus principle" which means that all relevant stakeholders involved in the apprenticeship system have to agree to a new training curriculum (Bundesinstitut für Berufsbildung, 2014). Thus, we might expect that, when the number of choice options is changed, $\int_i^N \alpha - \lambda_i$ is smaller after a modernization than before the modernization. Under this assumption, *any* change in the degree of heterogeneity would lead to an increase in firms' demand for apprentices.

#### 4.1.4. Effect via firms' market power

A change in the choice options in the training curriculum has additional effects on firms' post-training benefits via a change in their market power in the labor market for skilled workers. A more specific training curriculum creates monopsony power because it reduces the outside options of trained workers in the labor market as graduates can apply their skills in fewer outside firms. A significant share of firms employing skilled workers in the same occupation will prefer to hire a skilled worker with the reversed skill combination. Outside employers can observe the chosen specialization either on the apprenticeship leaving certificate, the work certificate, or the school certificate. Therefore, apprentices are more likely to stay in the training firm if they have been trained according to a more heterogeneous curriculum. This in turn increases firms' chances to recoup training investments incurred.

Moreover, firms are able to pay a lower wage relative to skilled workers' productivity. Assuming that—in line with Lazear's argumentation—the graduate's wage within the training firm is determined by a Nash bargaining process, the wage lies exactly between the graduate's productivity and his or her expected outside option. As the expected value of the outside options decreases in line with more heterogeneity in the curricula, the training firm is able to pay a lower wage.[9] This increases the potential return obtained from offering training, which will lead to an increase in firms' demand for apprentices.

Both because of the higher productivity of trained workers in the training firm *and* the stronger bargaining power of the firm, more possibilities to specialize in the training curriculum will lead to higher returns for the firm after the training period. Therefore, we derive the following hypothesis.

***H2:*** *More heterogeneity in the training curriculum increases the demand for apprentices in this occupation.*

With regard to the effect of less heterogeneity, we outlined two opposing effects. On the one hand, assuming that a change in the number of choice options leads to a better fit between acquired and demanded skills, less heterogeneity increases workers' productivity in the training firm. This would for example be the case if firms preferred to convey all skills to an equal degree and not to specialize in one skill. On the other hand, less heterogeneity will also decrease the bargaining power of the firm, which leads to higher wages for trained workers. Accordingly, the general positive effect of a change in the degree of choice options on the demand for apprentices would (partially) be compensated by higher wages and quit rates. It is not straightforward to see which of these two mechanisms has a stronger effect in practice. Therefore, no clear

[6] In the extreme case, a firm produces either with skill A ($\lambda_i = 1$) or skill B ($\lambda_i = 0$).

[7] We here deviate from Lazear's production function in order to model the decreasing marginal utility of one skill.

[8] The exact specification of the formula is not pivotal for the subsequent argumentation. It should only illustrate that firms prefer a training curriculum that matches their production process.

[9] Therefore, an alternative way to test the derived hypothesis would be to calculate the wage change when apprentices who were trained in modernized occupations change their employers (see for example Fitzenberger et al., 2015; Göggel & Zwick, 2012). However, we do not have any information on the wages at the level of apprenticeship occupations for the respective time span.

hypothesis on the effect of less heterogeneity on the demand for apprentices can be derived.

### 4.2. Supply of apprentices

Equivalent to hypothesis 1, modernizations are expected to have a positive effect on total supply of apprentices as trained apprentices will become more productive if a modernization aligns more closely the skills learned in the training with the skills demanded in the occupation. I.e., if the curriculum becomes more up to date, apprentices will be more productive after completion of training, which increases skilled workers' wages in the firm providing training. This higher wage makes apprenticeship training in recently modernized occupations more attractive. Thus, we can derive the following hypothesis.

***H3:*** *A modernization of the training curriculum leads to a higher supply of apprentices in this occupation.*

A modernization which leads to more heterogeneity in the curriculum might have two opposing effects on the supply of apprentices. On the one hand, more heterogeneity will lead to a better fit between the production process and the training content which will make trained workers more productive and will therefore increase their wage in the training firm. On the other hand, apprenticeship graduates will then also become more specialized and more dependent on the training firm. This would ceteris paribus reduce their outside options and the wage they can earn in another firm.[10] In case of a layoff, the apprentice would be more likely to suffer a wage loss. Therefore, more heterogeneity in the curriculum will reduce the graduates' bargaining power and their wage in the training firm. This makes an apprenticeship in occupations with a more heterogeneous curriculum less attractive. The effect of more heterogeneity in the training curricula on the supply of apprentices could therefore go in different directions, and we cannot derive a clear hypothesis.

The same countervailing effects could occur if a modernization leads to less heterogeneity in the curriculum on students' supply of apprentices. If the lower number of choice options leads on average to a worse fit between acquired and demanded skills, less heterogeneity will decrease workers' productivity in the training firm, whereas less heterogeneity in the curriculum will improve graduates' bargaining power as they will then have more outside options. However, even though theoretically the 'net' effect of heterogeneity in the training curricula on the supply of apprentices is not clear, we will assess this relationship empirically.

Table 1 gives an overview of the expected effects of the curriculum modernizations.

## 5. Data

### 5.1. Demand for and supply of apprentices

The data used for this analysis is based on the survey of New Training Contracts with the effective date of 30th of Sept of each training year.[11] It includes information about the number of new training contracts and the supply of and demand for apprentices. The new training contracts are collected by the Bundesinstitut für Berufsbildung (BIBB) from the responsible Chambers, which have information on all new training contracts in their associated occupations. The annual demand for apprentices is calculated by adding the new training contracts in the year to the number of unfilled training places the firms report to the German Federal Employment Agency. As firms have to report each training contract to the responsible Chamber, the Chambers are informed on all new training contracts. In principle, however, the Federal Employment Agency might not be informed by all training vacancies or searches. However, as long the share of not reported training vacancies or searches remains constant a deviation should not bias the results. The supply of apprentices is obtained by adding the new training contracts to the number of applicants who could not get an apprenticeship place and did not have any other alternative. Thus, our database is a full census of the complete demand for and supply of apprentices in Germany. The data does not include the number of firms that demand apprentices and the number of apprentices demanded per firm. Thus, we cannot say whether the results are a consequence of changes in the extensive or intensive margin of the demand for apprentices. The same holds for the supply of apprentices. Information about the supply of and demand for training contracts at the occupational level has been available since 2004.

The data set comprises information on the demand for and supply of apprentices in all 330 occupations that were recognized in 2014.[12] We had to gather information on the development of all occupations in order to construct a dataset with comparable occupations over time. Occupations should therefore be comparable before and after the modernization. Occupations that were split and merged at the same time could not be compared over time and are excluded from the analysis. In total, these were eight occupations. When an occupation had a different name in the past or results from a merge of different occupations, it is linked to its predecessor(s). In our analyses, we control for possible effects of a name change or mergers by including a name dummy as well as a dummy for mergers. In the event that the occupation has had several predecessors, we use the sum of the demand for (or supply of) apprentices of those predecessors and match this sum to the new occupation.[13] All training regulations are published under the Federal Law Gazette (Ger.: "Bundesgesetzblatt").

We exclude very small occupations when the occupation ever comprised less than 12 apprentices in any of the years between 2004 and 2014. Moreover, we excluded eight occupations, which could not be compared over time due to a complex restructuring in the course of a modernization.[14] In this way, we obtain a panel data set of 265 different occupations over 11 years. 244 occupations existed during the whole time period from 2004 to 2014; 21 occupations were introduced at a later stage and therefore existed only during a part of this period.

### 5.2. Curriculum heterogeneity

#### 5.2.1. Structure of the curricula

We base the categorization of the degree of heterogeneity in the curricula on the structure of the training, which is defined for each occupation in the training regulation (see Bundesinstitut für Berufsbildung, 2014). We ranked the five different training structures according to their degree of differentiation. Doing so, we take into account the number of specializations and the time these specializations take in relation to the total train-

[10] In this way, more heterogeneity would lead to a lower outflow of trained graduates to other firms. Unfortunately, there is no data on the outflow of apprentices successfully completing training to other firms at the occupational level.

[11] For information about the survey see: http://www.bibb.de/dokumente/pdf/naa309_BIBB-Erhebung_Zusammenfassung_201103.pdf.

[12] This also excludes the possibility that occupations that were abandoned are still in the dataset.

[13] As the data of the new training contracts are gathered by the Chambers of industry and commerce and the Chambers of craft, which sometimes incorrectly report the old name of the occupation, occupations that were not modernized in our research period also had to be matched to their predecessors.

[14] This is the case when occupations were split and the split parts were at the same time merged with other occupations.

ing time. The structure with elective qualification units, for example, allows for the highest number of possible combinations as firms can choose several out of many possible qualification units. In contrast, a structure including different disciplines means that firms can choose one discipline out of usually three or four disciplines. Therefore, the disciplines are mostly ranked lower than the qualification units. However, the internal differentiation is not only determined by the *number* of specializations but also by the *importance* these specializations have in relation to the total training content. For example, when a firm can choose between 100 specializations, but these specializations are only supposed to last for 1 week, they are likely to be not very relevant for the skill acquisition of the apprentice. Therefore, we also take into account the time these specializations take in relation to the total training time. As a result, when the elective qualification units account only for a relatively short time period (e.g., only half a year), they are ranked lower than the disciplines. According to the number and relevance of choice options, we yield the following ranking on the degree of heterogeneity for the different curricula structures from less to more heterogeneous: mono-occupations, fields of application, priority topics, elective qualification units (half a year) disciplines, and elective qualification units (full year).

*5.2.2. Defining the change in heterogeneity*

The amount of choice options, i.e. degree of heterogeneity, can only be changed in the course of a modernization. The operationalization of a modernization is straightforward as the result of a modernization is always the replacement of an old training curriculum by a new one. We allocated all modernizations into three groups: (1) modernizations creating less choice options in the curriculum, (2) modernizations that do not affect the choice options and (3) modernizations that allow for more curriculum heterogeneity.

In principle, changes in the degree of differentiation within an occupation can occur in four ways. Firstly, a curriculum could be given a different structure. For example, a change from, e.g., a mono-occupation to an occupation with disciplines is defined as a change toward more heterogeneity.[15] Secondly, the amount of possible specialization options can change within a given structure of the curriculum (e.g., a firm can choose between two instead of three possible disciplines). Thirdly, the time spent on existing specializations in the curriculum can change (elective qualification units should last 1 year instead of only half a year). Fourthly, when several occupations are merged into one occupation, the modernization is categorized as less heterogeneity.[16]

In the following, we provide three examples of modernizations that took place between 2005 and 2014, and explain why they are categorized into leading to more or less heterogeneity.

The occupation “insurance and financial services broker” was modernized in the year 2006. Before the modernization, the occupation was designed as a mono-occupation, which meant that all firms training apprentices in this occupation had to adhere to the same training curriculum and impart exactly the same skills. In 2006, the structure of the curriculum was converted into a curriculum with different disciplines. From then on, firms had the possibility to choose one out of two disciplines, i.e. either “financial advice” or “insurance”. Thus, this training curriculum entailed *more heterogeneity* after the modernization than before.

A second example is the occupation “designer of digital and print media”, which was modernized in the year 2013.[17] The occupation was merged with the occupations “decorative template maker”, “photographic laboratory technician”, and “photographic media laboratory technician”.[18] Thus, after the modernization the occupation “designer of digital and print media” was a combination of four different predecessor occupations. Although the new training curriculum allowed for choosing one of three disciplines (“advising and planning”, “conception and visualization”, and “design and technology”), the new merged occupation allows for *less heterogeneity* compared to the previous four separate occupations.[19]

The third example is the occupation “wood mechanic”, for which the number of choice options decreased. Before the modernization in 2006 firms could choose between six different disciplines, while from 2006 on, firms could only choose between two different disciplines (“furniture-making and interior fittings” and “construction elements, wooden packaging and frames”). The modernization therefore *decreased the heterogeneity* within this occupation.

The three examples of curriculum modernizations show that the categorization is based on both the curriculum structure and the number of choice options within the same structure. Moreover, mergers of occupations are taken into account.

The information about the modernizations is obtained from the BIBB database on occupations and their modernizations, which is available online. New training regulations always come into force in the month of August in the respective year. As the new training year always starts in September, all new training contracts concluded and reported within this year have to abide by the valid curricula of the respective year. For example, when the occupation “plant mechanic” is modernized in 2004, all firms concluding and reporting a new training contract for training the “plant mechanic” in 2004 have to train according to the new regulation.

Tables A1 and A2 in the Appendix show the respective training structures before and after the modernizations in the time period analyzed differentiated for modernizations leading to less (Table A1) and more (Table A2) heterogeneity.

Table 2 provides an overview of how those modernizations in the different years are categorized. In the period from the years 2005 to 2014, 103 modernizations were implemented, whereas six occupations were modernized twice (among those were five evaluable occupations).[20] Thus, in these years 97 occupations were modernized. For our analysis, we can make use of 85 different modernizations. Seven modernizations had to be excluded because they led to a split and a merge of several occupations at the same time, something which impedes a comparison between the pre- and post-treatment period.[21] One occupation was merged twice in the observed time period. In order to compare this occupation over the different years, only the second modernization was analyzed.[22] Ten modernizations were excluded because they affected

[15] We assume that potential additional options are also used by firms as the modernizations are initiated by the firms themselves due to changing skill requirements.

[16] We also included a separate dummy on mergers to test for potential separate effect of merged occupations. Splits of occupations are not part of our database.

[17] See https://www.bibb.de/de/berufeinfo.php/genealogy/nmedpr13 for the historical development of this occupation.

[18] The translation are taken from: https://www.darmstadt.ihk.de/produktmarken/aus_und_weiterbildung_channel/ausbildung_channel/Anlagen_Artikel/englische_berufsbezeichnungen/2535860.

[19] In our empirical analysis, the number of apprenticeships of a merged occupation will be compared to the sum of the number of apprenticeships of the predecessor occupations.

[20] For occupations that were modernized in 2004, we cannot compare a pre- and post-modernization period.

[21] A detailed description of the unambiguous modernization is available upon request.

[22] In the empirical analysis, this second modernization is defined as the first modernization.

**Table 2**
Curriculum modernizations between 2005 and 2014.

| Year | Modernizations | Less heterogeneity | No change in heterogeneity | More heterogeneity |
|---|---|---|---|---|
| 2005 | 15 | 6 (3) | 6 | 3 |
| 2006 | 16 | 4 (2) | 7 | 5 |
| 2007 | 5 | 0 (0) | 4 | 1 |
| 2008 | 2 | 1 (0) | 0 | 1 |
| 2009 | 6 | 1 (1) | 1 | 4 |
| 2010 | 8 | 1 (0) | 5 | 2 |
| 2011 | 9 | 1 (0) | 2 | 6 |
| 2012 | 5 | 0 (0) | 3 | 2 |
| 2013 | 12 | 4 (3) | 6 | 2 |
| 2014 | 7 | 3 (1) | 4 | 0 |
| Total | 85 | 21 (10) | 38 | 26 |

***Note:*** The number of merged occupations leading to less heterogeneity is displayed in parentheses in the third column. Modernized occupations that were split cannot be compared over time. These occupations are not included in the analysis. Moreover, curriculum modernizations for very small occupations (with fewer than 12 apprentices) are also not included.

very small occupations with fewer than twelve apprentices.[23] From the 85 modernized occupations, 21 became more homogenous, 26 became more heterogeneous, and 38 did not change their structure at all. As can be seen in Table 2, in each year at least two modernizations occurred, with peaks in the years 2005, 2006 and 2013.

The Tables A3 and A4 show for each occupation the demand for and supply of apprentices in the year before the modernizations that lead to less and more heterogeneity, respectively. Table A5 in the Appendix shows the mean demands which indicate the "size" of the occupations. The average demand for apprentices in each training year over the 265 occupations and the 11 years is 2215. The demand for apprentices seems to be higher when modernizations are associated with a change in the heterogeneity of the curriculum (less heterogeneity: 3650 and more heterogeneity: 3492) in comparison to both the occupations with curriculum modernizations that did not entail a change in heterogeneity (1857) and occupations that were not modernized at all (1955).[24] However, the demand for apprentices does not appear to differ much between modernizations leading to more heterogeneity vs. modernizations leading to less heterogeneity. Table A5 also shows that occupations that have been modernized twice tend to be associated to the highest demand for apprentices. This makes sense as it is likely that more important large occupations are more often modernized.

## 6. Empirical strategy

### 6.1. Model

We first estimate occupational fixed-effect regressions in which we relate the demand for apprentices to the modernizations in the training curricula. To test the effect of changes in the degree of heterogeneity, we include two interaction terms indicating whether the modernization introduced more or less heterogeneity in the training curriculum. The occupational fixed-effect regression is therefore specified as follows:

$$D_{ot} = occ_o + \beta_1\, mod_{ot} + \beta_2\, het_{ot} + \beta_3\, hom_{ot} + \delta_t dt + \gamma_o t_o + \varepsilon_{ot} \quad (3)$$

$D_{ot}$ denotes the demand for apprentices in year $t$ and occupation $o$. The indicator variable $occ_o$ denotes the dummies for the different occupation. The variable $mod_{ot}$ is 1 if an occupation is modernized and 0 if it is not yet or has never been modernized. Thus, the parameter $\beta_1$ estimates the effect of the modernization itself. Five occupations that were modernized twice in the time period were analyzed. For these occupations, we used a second modernization dummy (not displayed in Eq. (3)). To measure the effect of changes in curriculum heterogeneity, we include interaction terms indicating modernizations that allow for more heterogeneity ($het_{ot}$) and modernizations that lead to less heterogeneity, i.e. more homogeneity ($hom_{ot}$). If the modernization implied a change toward more heterogeneity, $het_{ot}$ takes the value 1 in the years after the modernization and 0 in the years before the modernization. When there was no change in the structure of the curriculum at all or when the number of choice options was reduced, the variable $het_{ot}$ is always equal to 0. The values for $hom_{ot}$ are analogous. Thus, $\beta_2$ and $\beta_3$ estimate the effect of more or less heterogeneity respectively. Thus, the coefficient $\beta_1$estimates the effect of a modernization, when there was no change in the degree of heterogeneity. As controls, the following variables are included: year dummies $dt$ and occupation-specific time trends $t_o$. By the inclusion of the year dummies, we can exclude year specific exogenous shocks affecting the demand for apprentices, such as cohort-specific demographic changes, changes in the number of school leavers and business cycle effects. The occupation-specific time trends control for any occupation specific upward or downward trend in the number of apprenticeships.

Analogously, we also run a regression in which we analyze to what extent more or less heterogeneity in the curriculum introduced by the modernization affects the supply of apprentices:

$$S_{ot} = occ_o + \beta_1\, mod_{ot} + \beta_2\, het_{ot} + \beta_3\, hom_{ot} + \delta_t dt + \gamma_o t_o + \beta_4 name_{ot} + \varepsilon_{ot} \quad (4)$$

This regression includes the same variables of interest and control variables as the regressions on the demand for apprentices. Moreover, we include an additional control variable $name_{ot}$ which indicates whether or not the name of the occupation has been changed in the course of the modernization. Correspondingly, $\beta_4$ estimates potential changes in the attractiveness of the occupation due to a name change. Krewerth et al. (2004) show that the name of the occupation has a significant effect on the occupational choice of young school leavers. If policy makers choose a more attractive name, a name change might be associated with an increase in the supply of apprentices in this occupation.

[23] From all the small occupations that were modernized in the respective time span, no occupation was introduced in the analyzed time span. Therefore, there is no risk of neglecting small emerging occupations.

[24] It should however be noted that the more recent modernizations leading to more heterogeneity in the curriculum remarkably took place in smaller occupations. Data are available upon request.

### 6.2. Exogeneity of curriculum modernizations

Even though training curricula should correspond to the production process of the employers and, accordingly, modernizations occur after fundamental changes in the production process, we argue that both the content and timing of modernizations of training curricula can be considered as exogenous.

First, the design of training curricula is *not only* determined by employers' interests. By law, different stakeholders are involved in the modernization process (employer associations, unions, representatives of federal states, the national government, and the Federal Institute for Vocational Education and Training). The initiative for a modernization of the curriculum may come from any of these stakeholders and all relevant stakeholders have to agree that a new training curriculum will be introduced (i.e., the "consensus principle"). Moreover, individual firms do not have any direct influence in this process but are represented by associations. Therefore, large firms tend to have more influence on the curricula modernizations as small and medium sized firms are often not part of sector associations and the representatives of employer associations usually come from large companies.

Second, modernizations are *not immediately* implemented after a change in the production process. It is a long process until an occupation is modernized. If social partners request to considerate a curriculum modernization they have to make a proposal including the basic aspects of the proposed new curriculum (the 'benchmark figures") and propose the modernization via their umbrella organizations to the relevant ministry.[25] After setting the benchmark figures with the approval of the relevant ministry, the training curricula are developed parallel to the elaboration of the framework curriculum for vocational schools. The draft of the training curriculum has to be commented by the Board of the Federal Institute for Vocational Education and Training (BIBB). Finally, the regional state ministries, the Federal Ministry of Education and Research and the ministries responsible for the training regulation must give their final approval before the ministry responsible for the occupation can adopt the training curriculum. Usually, the curriculum then comes into force the following August. Due to the high effort of the various engaged parties and the length of the process, occupations are not regularly modernized. In the 11 years of our research period only 85 out of a total of 265 occupations were modernized and only 5 occupations were modernized twice. Moreover, there is always a considerable and irregular lag between the perceived needs for a curriculum modernization and its implementation. The exact year of a modernization is therefore quite random. From this annual perspective, modernizations can be seen as an exogenous change in the framework conditions.

One might argue that choice options might have been accidentally introduced in the same year of other unobserved changes that might also have affected demand for and supply of apprentices. Such changes could refer to the business cycle or the demographic situation. By including year dummies and occupation-specific time trends, we try to rule out this potential endogeneity. Moreover, in one of our robustness tests in Section 7.2, we test for pre-treatment time trends in the demand for and supply of apprentices in occupations that have been modernized.

## 7. Results

### 7.1. Regression results

Table 3 shows the estimation results of the occupation fixed-effect regression on the demand for and supply of apprentices. As we analyze five occupations that were modernized twice in the respective time period, we include a control dummy for the second modernization and interaction terms indicating whether or not the second modernization was associated with more (or less) heterogeneity.

The estimation results show that most of the time curriculum modernizations as such are not significantly associated with firms 'demand for apprentices. Nonetheless, as the data source is a full census, the non-significant coefficients can also be interpreted meaningfully.[26] The coefficient suggests that modernizations are slightly positively associated to firms' demand for apprentices. Considering the first modernizations, which make up 93% of all modernizations, a modernization as such is associated to an increase of the firms' demand with 56 apprentices, which corresponds to 2% of the average number of demanded apprentices before the modernizations.[27]

Including the interaction variables on whether the modernizations were associated with more or less heterogeneity decreases the coefficient for the first modernizations. The coefficient for modernizations creating more heterogeneity is positive and significant at the 5% level. Considering the average demand for apprentices of 2215, the coefficient for the first modernization implies a substantial increase of 14% in firms' demand for apprentices.

This shows that modernizations of the curriculum only successfully increase the demand for apprentices if firms receive more opportunities to adapt the training to their needs. These results confirm hypothesis 2 and reject hypothesis 1. Moreover, they support the theory that the positive effect of modernizations on a firm's demand for apprentices is indeed channeled via the firm's post training benefits and not via the training costs. Training could become less costly after any modernization, but it is only the heterogeneity which leads to an increased wedge between productivity and wages.

The estimation results also show that modernizations that reduce the heterogeneity in the curriculum decrease the demand for apprentices by 209, which is a decrease of 9%. We also test for a separate effect of merged occupations by including a variable indicating whether the modernization consisted of a merger of occupations (column 3). The results show that the negative effect of less heterogeneity is mainly due to modernizations that combined several occupations into one. Including this control variable, the coefficient for less heterogeneity increases and the coefficient for the merge of occupation is −336 and significant at the 10% level.

Table 3 also shows the estimation results on the supply of apprentices (columns 4–6). These results seem to be rather similar to the estimation results on firms' demand for apprentices.[28] Modernizations as such appear to have an insignificant effect on the supply of apprentices. Thus, we have to reject hypothesis 3. However, students are more likely to apply for occupations that provide more heterogeneity in the training curriculum as the coefficient for more heterogeneity in the curricula is positive (205) and significant. When comparing these results to the estimation results for the demand for apprentices, one can see that the former coefficients are slightly smaller (at least for the first modernizations). This suggests that the supply of apprentices is less sensitive to hav-

[25] Most often the Ministry of Economics and Energy, but for some occupations it should be proposed to another ministry (e.g. Ministry of Environment).

[26] Usually, the significance levels indicate the probability that the estimate is true in the population. In this case, we already have administrative data from the whole population, i.e. supply of new training contracts. For a description of the dataset, see Flemming and Granath (2011).

[27] The average number of demanded apprentices before the modernizations was 2741.

[28] This could be expected as excess supply or demand is usually not large because the majority of all firms that supply apprenticeships also find apprentices whereas most students who would like to have an apprenticeship find one. When we regress the number of new apprenticeship contracts (i.e., matched supply and demand) on the same explanatory variables, the estimation results are also very similar.

**Table 3**
FE-regressions: demand for and supply of apprentices.

| | Demand for apprentices | | | Supply of apprentices | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Modernized (before/after) | 55.68 | 15.55 | 15.48 | 41.49 | -0.94 | 8.06 |
| | (1.32) | (0.25) | (0.25) | (0.83) | (−0.01) | (0.12) |
| More heterogeneity | | 317.83** | 318.62** | | 205.47* | 204.75* |
| | | (3.23) | (3.24) | | (2.26) | (2.25) |
| Less heterogeneity | | -209.41* | -38.24 | | -57.68 | 3.22 |
| | | (−2.01) | (−0.28) | | (−0.59) | (0.03) |
| Merge of occupations | | | -335.53* | | | -125.60 |
| | | | (−2.00) | | | (−0.77) |
| Constant | 166,445.89 | 155,262.24 | 156,608.42 | 186,269.15 | 179,077.74 | 179,463.72 |
| | (0.18) | (0.17) | (0.17) | (0.22) | (0.21) | (0.21) |
| Occupation-specific year trends | Yes | Yes | Yes | Yes | Yes | Yes |
| Occupation FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Controls for second modernizations | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of occupations | 265 | 265 | 265 | 265 | 265 | 265 |
| Observations | 2843 | 2843 | 2843 | 2843 | 2843 | 2843 |
| $R^2$ | 0.69 | 0.69 | 0.69 | 0.79 | 0.80 | 0.80 |

*Note:* Occupation fixed-effects regressions. T-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Regression additionally controls for year dummies and name changes (in the supply regressions).

ing more heterogeneity in the curriculum than the firm's demand for apprentices.

Moreover, modernizations which lead to more homogeneous curricula are not significantly related to the supply of apprentices. The positive coefficient of more heterogeneity could suggest that more choice options always enhance the graduates' productivity.

### 7.2. Robustness tests

#### 7.2.1. Only a temporary effect?

In order to test whether the effect of the modernization is particularly large in the first year after the modernization and levels off in the following years, we created a variable which is one for the immediate year after the modernization and zero in all other years. We further created two variables indicating the interaction between the first year after the modernization and the change toward more or less heterogeneity. The variables are again 1 for the year immediately after the modernization that leads to more (or less) heterogeneity and zero in all other years. We estimated the two baseline regressions for supply and demand (shown again in columns 1 and 4 of Table 4), respectively,[29] including these control variables (see columns 2 and 5 of Table 4). The estimation results show that the first year after the modernization does not have an additional significant effect on firms' demand for or the supply of apprentices. Moreover, in both the supply and demand regressions, the estimation results on the effects of modernization remain robust showing that more heterogeneity in the curriculum increases both demand for and supply of apprentices.

#### 7.2.2. Anticipation effect before the modernization

The increase in supply and demand after modernizations that increase curriculum heterogeneity could also be due to a dip in the supply and/or demand in the year before the modernization, if firms and students anticipated the modernization and postponed the training to the next year when the modernized curriculum was introduced. To test whether this could be a driver of the effects of the modernization, we also added a dummy variable for the year immediately before the modernization to the baseline regression. Again, we also construct interaction terms, which differentiate between modernizations creating more and less heterogeneity. The estimation results presented in Table 4 (columns 3 and 6) show that the coefficients for modernization creating more heterogeneity even become larger, whereas the coefficients of the dummy variable for the last year before the modernization with more heterogeneity are also significantly positive. This suggests that firms already tend to increase their demand for apprentices 1 year before the modernization anticipating that the training curricula will be modernized and more choice options will be introduced.[30]

Moreover, we tested for different pre-treatment time trends of the demand for and supply of apprentices in occupations that have been modernized in comparison to demand and supply in occupations that have not been modernized.[31] The estimation results show that there is no significant difference in the pre-treatment trends between the modernized and not modernized occupations. Additionally, we did a similar test for different pre-treatment time trends of the demand for and supply of apprentices in occupations in which the modernization lead to more heterogeneity in the curriculum. Again, we did not find a significant difference in the pre-treatment trends between the occupations in which the curriculum became more heterogeneous and the not modernized occupations.[32]

Finally, we also did a placebo test to test whether apprenticeship demand was reduced in the years before the modernizations that lead to more heterogeneity as an anticipation effect. We therefore assumed that the modernization took place 4 years before the actual modernization year, and created a placebo dummy variable that is 1 for all 4 years after the assumed modernization year. A Dif-in-Dif analysis between the falsely treated (modernized) occupations and the other occupations shows that there is no significant difference in the demand for and supply of apprentices between the years before and after the placebo modernization.[33]

[29] If we take the regression in columns 3 and 6 of Table 3 as baseline regressions, including these control variables has similar effects.

[30] The results remain also robust when we control for the three years before the modernization. Results are available upon request.

[31] We here tested whether the pre-treatment supply and demand trends of all occupations that have been modernized after the year 2008 differ from the supply and demand trends of the occupations that have not been modernized in our research period by regressing demand and supply on a dummy variable, which indicates whether the occupation has been modernized, a time trend and an interaction term of the two variables. Estimation results are available upon request.

[32] Estimation results are available upon request.

[33] We here again focused on the modernizations that took place after the year 2008. Estimation results are available upon request.

**Table 4**
FE-regressions: demand for and supply of apprentices (robustness tests).

| | Demand for apprentices | | | Supply of apprentices | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Modernized (before/after) | 15.55 | 21.00 | -0.16 | -1.09 | -26.52 | -61.47 |
| | (0.25) | (0.29) | (−0.00) | (−0.02) | (−0.35) | (−0.69) |
| More heterogeneity | 317.83** | 322.40** | 646.90*** | 209.72* | 209.49* | 537.94*** |
| | (3.23) | (2.80) | (4.56) | (2.31) | (1.97) | (4.11) |
| Less heterogeneity | -209.41* | -225.64 | -275.84 | -61.32 | -46.25 | 51.29 |
| | (−2.01) | (−1.81) | (−1.79) | (−0.63) | (−0.40) | (0.36) |
| First year after modernization | | -10.16 | -6.19 | | 47.19 | 54.07 |
| | | (−0.14) | (−0.08) | | (0.70) | (0.80) |
| First after modernization with more heterogeneity | | -9.05 | -80.90 | | 1.57 | -71.08 |
| | | (−0.08) | (−0.72) | | (0.02) | (−0.68) |
| First after modernization with less heterogeneity | | 29.31 | 34.48 | | -28.64 | -45.85 |
| | | (0.24) | (0.28) | | (−0.25) | (−0.40) |
| Last year before modernization | | | -30.50 | | | -53.47 |
| | | | (−0.39) | | | (−0.75) |
| Last year before modernization with more heterogeneity | | | 459.38*** | | | 466.84*** |
| | | | (3.79) | | | (4.17) |
| Last year before modernization with less heterogeneity | | | -73.59 | | | 142.31 |
| | | | (−0.55) | | | (1.15) |
| Constant | 155,262 | 155,514 | 157,810 | 179,003 | 176,230 | 177,376 |
| | (0.17) | (0.17) | (0.17) | (0.21) | (0.20) | (0.21) |
| Number of occupations | 265 | 265 | 265 | 265 | 265 | 265 |
| Observations | 2843 | 2843 | 2843 | 2843 | 2843 | 2843 |
| $R^2$ | 0.69 | 0.69 | 0.69 | 0.80 | 0.80 | 0.80 |

*Note:* Occupation fixed-effects regressions controlling for anticipation and short-term effects. Regression controls for year dummies, name changes, and occupation-specific year trends, and second modernizations. T-statistics are in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

## 8. Conclusion

In this paper, we make use of the modernizations of training curricula to find the effects of creating more or less heterogeneity in the contents of a training curriculum on the demand for and supply of apprentices.

We find that a modernization of the curriculum in itself does not increase the demand for and supply of apprentices. However, modernizations that lead to more heterogeneity in the training curriculum increase both the demand for and the supply of apprentices in the occupation.

The positive effect on the firms' demand for apprentices can be explained as follows. A modernization, which enables firms to fit the curriculum more closely to the specific requirements of their production process, improves the match between the content of the curriculum and firms' training needs. This makes it likely that apprenticeship training becomes more effective and graduated apprentices more productive. Firms could then expect higher post-training benefits from their apprentices. Moreover, more specific curricula could also increase the market power of firms, which enables them to pay wages that are below workers' productivity. And last but not least, firms might benefit from lower net training costs because more specific training will be more in line with the firms' production process.

The finding that a more heterogeneous curriculum also increases the supply of apprentices could be explained by a positive effect on skilled worker wages because of the apprentices' higher productivity as they acquire more skills that they can apply in their job.[34] This positive effect appears to overrule the potentially negative effect due to their lower market power because of the more specialized training (see Section 4.2).

Our finding that modernizations leading to more heterogeneity are more likely to take place in larger occupations suggests that these modernizations could be less beneficial for small training occupations. This could particularly hold when the employment opportunities of a vocational training become too small from the apprentice's perspective. From this we might conclude that it is beneficial for both firms and apprentices to create sufficiently large occupations, but allowing for specialization options within these large occupations. It should however be noted that the more recent modernizations leading to more heterogeneity in the curriculum took place in smaller occupations. The latter suggests that specific characteristics of occupations are also relevant here.

It should also be noted that our finding that having sufficient choice options in the training curriculum is important for the attractiveness of a curriculum for both firms and apprentices, does not exclude that it might also be important to ensure certain standardization, because too much heterogeneity will give graduated apprentices very few chances outside their training firm. Our findings suggest that the modernizations that lead to more specialization did retain sufficient standardization. Probably also for firms, some standardization of the contents of the training curriculum could have positive effects because having too much heterogeneity in the curriculum would restrict their possibilities to recruit skilled workers from other firms. The number of suitable skilled workers would then fully depend on the firm's own engagement in apprenticeship training. Our findings show that the modernizations that increased heterogeneity in the curricula of apprenticeship training in Germany retained sufficient standardization to prevent these potential adverse effects.

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## Appendix

Table A1, Table A2, Table A3, Table A4, Table A5.

[34] The available data does not allow us to estimate the effect of heterogeneity on skilled worker wages.

**Table A1**
Modernizations leading to less heterogeneity.

| Year | Occupation | Number and type of choice options | | |
|---|---|---|---|---|
| | | Before modernization | After modernization | Merger |
| 2005 | Building materials tester | Disciplines (1 out of 3) | Priority topics (1 out of 3) | No |
| | Industrial ceramist, decorative engineering | Disciplines (2 out of 2) | Mono-occupation | No |
| | Textile production mechanic | 12 predecessor occupations | Mono-occupation | Yes |
| | Textile product finisher | 2 predecessor occupations | Mono-occupation | Yes |
| | Saddler | 4 predecessor occupations | Disciplines (1 out of 3) | Yes |
| | Tourism services management clerk | Disciplines (1 out of 2)+fields of application (1 out of 3) | Fields of application (1 out of 3) | No |
| 2006 | Port boatman | 2 predecessor occupations | Mono-occupation | Yes |
| | Wood mechanic | Disciplines (1 out of 6) | Disciplines (1 out of 2) | No |
| | Media agent for digital and print media | Priority topics (1 out of 2) | Mono-occupation | No |
| | Builder of stoves and air heating systems | 2 predecessor occupations | Mono-occupation | Yes |
| 2008 | Protection and safety specialist | Fields of application (1 out of 4) | Mono-occupation | No |
| 2009 | Technical model-maker | 2 predecessor occupations | Disciplines (1 out of 3) | Yes |
| 2010 | Paper technologist | Disciplines (1 out of 2) 52 weeks | Elective qualification units (2 out of 12) 26 weeks | No |
| 2011 | Screen print media technologist | Elective qualification units (2 out of 5)+(2 out of 8)+(1 out of 7) (44 weeks) | Elective qualification units (2 out of 11)+(1 out of 7) (52 weeks) | No |
| 2013 | Skilled metal worker | 11 predecessor occupations | Disciplines (1 out of 4) | Yes |
| | Aircraft electronics technician | Fields of application (1 out of 5) | Fields of application (1 out of 4) | No |
| | Motor vehicle mechatronics technician | 2 predecessor occupations | Priority topics (1 out of 5) | Yes |
| | Designer of digital and print media | 4 predecessor occupations | Disciplines (1 out of 3) | Yes |
| 2014 | Office Manager | 3 predecessor occupations | Elective qualification units (2 from 10) | Yes |
| | Technologist in confectionery goods | Disciplines (1 out of 3) | Fields of application (1 out of 5) | No |
| | Motor vehicle body and vehicle construction mechanic | Disciplines (1 out of 3) | Disciplines (1 out of 2) | No |

**Table A2**
Modernizations leading to more heterogeneity.

| Year | Occupation | Number and type of choice options | |
|---|---|---|---|
| | | Before modernization | After modernization |
| 2005 | Butcher | Disciplines (1 out of 3) | Elective qualification units (2 out of 6) |
| | Surface coater | Mono-occupation (3 alternatives) | Mono-occupation (4 alternatives) |
| | Animal caretaker | Mono-occupation | Discipline (1 out of 5) |
| 2006 | Salesperson specializing in foodstuffs | Priority topics (1 out of 2) | Priority topics (1 out of 3) |
| | Property agent | Mono-occupation | Elective qualification units (2 out of 5) |
| | Insurance and financial services broker | Mono-occupation with elective modules (2 out of 3 modules) | Disciplines (1 out of 2) |
| | Media designer for images and sound | Mono-occupation | Fields of application (1 out of 10) |
| | Mechanic in plastics and rubber processing | Mono-occupation with 4 priority topics | Mono-occupation with 6 priority topics |
| 2007 | Management assistant for retail services | Elective qualification units (1 out of 4)+(4 out of 7) | Elective qualification units (1 out of 4)+(4 out of 8) |
| 2008 | Hairdresser | Mono-occupation | Elective qualification units (1 out of 5) |
| 2009 | Mining technologist | Mono-occupation | Disciplines (1 out of 2) |
| | Photographer | Mono-occupation | Priority topics (1 out of 4) |
| | Industrial ceramist | Disciplines (1 out of 3) | Elective qualification units (1 out of 6) |
| | Specialist retail assistant for the music branch | Mono-occupation | Elective qualification units (1 out of 3) |
| 2010 | Precision machinist | Priority topics (1 out of 3) | Priority topics (1 out of 4) |
| | Equine manager | Priority topics (1 out of 4) | Disciplines (1 out of 5) |
| | Boat builder | Mono-occupation | Disciplines (1 out of 2) |
| | Bookbinder | Disciplines (1 out of 3) | Elective qualification units (2 out of 9)+(1 out of 2) |
| | Bookseller | Priority topics (1 out of 3) | Elective qualification units (1 out of 3) |
| 2011 | Print media technologist | Disciplines (1 out of 4) | Elective qualification units (2 out of 21 + 1 out of 13) |
| | Packaging materials technologist | Elective qualification units (2 out of 8) | Elective qualification units (2 out of 4)+(2 out of 6) |
| | Tourism services management clerk | Fields of application (1 out of 3) | Elective qualification units (1 out of 3) |
| 2012 | Luminous advertisement maker | Mono-occupation | Priority topics (1 out of 2) |
| | Mechanic in plastics and rubber processing | Priority topics (1 out of 6) | Disciplines (1 out of 7) |
| 2013 | Orthopedic technician | Mono-occupation | Priority topics (1 out of 3) |
| | Materials tester | Mono-occupation | Disciplines (1 out of 4) |

**Table A3**
Demand for and supply of apprentices in the year before modernizations leading to less heterogeneity.

| | Year of modernization | Demand | Supply |
|---|---|---|---|
| Building materials tester | 2005 | 180 | 179 |
| Industrial ceramist, decorative engineering | 2005 | 39 | 42 |
| Textile production mechanic | 2005 | 486 | 495 |
| Textile product finisher | 2005 | 246 | 238 |
| Saddler | 2005 | 162 | 162 |
| Tourism services management clerk | 2005 | 2832 | 3060 |
| Port boatman | 2006 | 21 | 21 |
| Wood mechanic | 2006 | 1401 | 1450 |
| Media agent for digital and print media | 2006 | 836 | 855 |
| Builder of stoves and air heating systems | 2006 | 145 | 139 |
| Protection and safety specialist | 2008 | 1140 | 1203 |
| Technical model-maker | 2009 | 482 | 480 |
| Paper technologist | 2010 | 213 | 214 |
| Screen print media technologist | 2011 | 148 | 148 |
| Skilled metal worker | 2013 | 1133 | 1162 |
| Aircraft electronics technician | 2013 | 118 | 118 |
| Motor vehicle mechatronics technician | 2013 | 22,109 | 22,226 |
| Designer of digital and print media | 2013 | 3704 | 3925 |
| Motor vehicle body and vehicle construction mechanic | 2014 | 1446 | 1420 |
| Office Manager | 2014 | 31,578 | 32,648 |
| Technologist in confectionery goods | 2014 | 92 | 90 |

**Table A4**
Demand for and supply of apprentices in the year before modernizations leading to more heterogeneity.

| | Year of modernization | Demand | Supply |
|---|---|---|---|
| Butcher | 2005 | 3564 | 3484 |
| Surface coater | 2005 | 285 | 270 |
| Animal caretaker | 2005 | 585 | 602 |
| Salesperson specializing in foodstuffs | 2006 | 12,865 | 12,585 |
| Property agent | 2006 | 2104 | 2138 |
| Insurance and financial services broker | 2006 | 5299 | 5219 |
| Media designer for images and sound | 2006 | 631 | 773 |
| Mechanic in plastics and rubber processing | 2006 | 2161 | 2189 |
| Management assistant for retail services | 2007 | 32,666 | 36,848 |
| Hairdresser | 2008 | 18,371 | 19,460 |
| Mining technologist | 2009 | 79 | 76 |
| Photographer | 2009 | 864 | 909 |
| Industrial ceramist | 2009 | 43 | 43 |
| Specialist retail assistant for the music branch | 2009 | 33 | 35 |
| Precision machinist | 2010 | 2819 | 2805 |
| Equine manager | 2010 | 920 | 929 |
| Boat builder | 2011 | 127 | 127 |
| Bookbinder | 2011 | 425 | 416 |
| Bookseller | 2011 | 677 | 685 |
| Print media technologist | 2011 | 1073 | 1060 |
| Packaging materials technologist | 2011 | 478 | 473 |
| Tourism services management clerk | 2011 | 2001 | 2022 |
| Luminous advertisement maker | 2012 | 419 | 413 |
| Mechanic in plastics and rubber processing | 2012 | 2813 | 2720 |
| Orthopedic technician | 2013 | 479 | 471 |
| Materials tester | 2013 | 385 | 382 |

**Table A5**
Average demand for apprentices for different types of modernizations.

| | Average demand for apprentices | Std. Dev. | Frequency |
|---|---|---|---|
| Never being modernized | 1955 | 3746 | 1967 |
| Only one modernization | 2419 | 5766 | 821 |
| Two modernizations | 8482 | 11,827 | 55 |
| Less heterogeneity | 3650 | 8967 | 220 |
| Modernization (no change in het.) | 1857 | 3768 | 392 |
| More heterogeneity | 3492 | 7007 | 264 |
| No modernization | 1955 | 3746 | 1967 |
| Total | 2215 | 4772 | 2843 |

***Note:*** Average demand refers to the total time period from 2004 to 2014; the second part of the table only refers to the first modernization.

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